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MAGNETIC FIELD MEASUREMENTS BY PIONEER 7

I. Hourly Averages of the Field Elements from 17 August 1966 to 29 October 1967 (Bartels' Solar Rotation 1820 to 1836)

NORMAN F. NESS
FRANKLIN W. OTTENS

NOVEMBER 1971

GSFC — GODDARD SPACE FLIGHT CENTER
GREENBELT, MARYLAND

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Norman F. Ness
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Laboratory for Extraterrestrial Physics
NASA-Goddard Space Flight Center
Greenbelt, Maryland USA 20771

November 1971

1. Introduction

The Pioneer 7 spacecraft is a spin stabilized interplanetary probe launched from the Eastern Test Range, Cape Kennedy, Florida on 17 August 1966. The geocentric orbit of the spacecraft has an aphelion of 1.125 AU, a perihelion 1.010 AU, inclination to the ecliptic of 0^{o} and orbital period of 403 days. This spacecraft was the first of a series of four Pioneer spacecraft with identical structures but slightly different complements of experiments. A NASA-GSFC magnetic field experiment was proposed, accepted and flown on Pioneers 6 (in 1965) and 7. Subsequently, unique circumstances presented an opportunity for flight of a similar experiment by the GSFC group in collaboration with the University of Rome, Laboratory for Space Plasma Research group on Pioneer 8 (in 1967).

The magnetic field experiment detector is a monoaxial fluxgate magnetometer sensor mounted on the end of a boom at a distance of 2.1 meters from the spacecraft spin axis. The initial spin period was approximately one second and the field measurements were synchronized with the rotation of the spacecraft. The monoaxial sensor was oriented at an angle of 54^{o} 45' to the spin axis so that during one spacecraft rotation three samples of the magnetic field at equal intervals yielded three independent measurements in mutually orthogonal directions. These basic measurements, obtained in a time interval of 2/3 of a second, define the total vector magnetic field in a spacecraft coordinate system.

The spin axis of the spacecraft was oriented orthogonal to the ecliptic plane with the high gain antenna of the spacecraft pointing to the south ecliptic pole.

Data transmission from the spacecraft experiment was synchronized with telemetry, which ranged from 8 to 512 bits/sec during the lifetime of the spacecraft. A complete three component measurement was not read out during each spin period and so individual data points are not equally spaced in time (see Scearce et al., 1968 for description of the experiment).

The Pioneer 7 instrument was a single range magnetometer ($\pm 32\gamma$) which with the 8 bit quantization of the analog to digital converter yielded a digital window size of $\pm 0.125\gamma$. The RMS noise level of the sensor was 0.12γ and the bandwidth 0 to 5 cps. The magnetic field of the spacecraft and associated solar array as measured at the sensor location was estimated to be less than 0.6γ. Periodic sensitivity calibrations were made once each day as well as zero level checks approximately once every several months. The projection of the orbit described by Pioneer 7 on the ecliptic plane, relative to the earth-sun-line, is shown in Figure 1.

2. Data

The magnetic field elements have been computed in a spacecraft centered solar ecliptic system in which the X axis points from the spacecraft to the sun, the Z axis to the ecliptic north pole and the Y axis being the third axis of the orthogonal right handed coordinate system.

The standard data analysis was performed to yield 30 second averages of the field components and the field magnitudes as

$$\overline{X} = \frac{1}{n} \sum_{i=1}^{n} X_i \text{ etc., } \overline{F} = \frac{1}{n} \sum_{i=1}^{n} F_i, \quad \overline{\overline{F}} = \sqrt{(\overline{X})^2+(\overline{Y})^2+(\overline{Z})^2} \qquad (1)$$

Also RMS deviations $(\delta_X, \delta_Y, \delta_Z)$ of the magnetic field were computed routinely for each component and for the field magnitude. The Pythagorean variance, which is an invarient of the coordinate system, is obtained from the component deviations as

$$\delta = \sqrt{\delta_X^2 + \delta_Y^2 + \delta_Z^2} \qquad (2)$$

The choice of a 30 second time interval was based upon a desire to provide correlative data to each of the plasma probes on the Pioneer 6 and 7 spacecraft whose fastest cycle times were on the order of one minute.

Data shown in Figures 2 through 17 represent for each solar rotation the hourly averages of the field elements $\overline{F}$, $\overline{\overline{F}}$, θ (latitude) and ϕ (longitude). The data are plotted in 27 day increments corresponding to Bartels' solar rotation numbering system. The two variances D_1 and D_2 are obtained by different means. D_1 is a variance computed from equation 2 for each hourly interval using the hourly averaged components (and deviations from them). D_2 is the hourly average of the individual Pythagorean variance for each 30 time interval. The days of the year are indicated as calendar days and most of the missing data corresponds to gaps in tracking coverage of the spacecraft. Publications utilizing Pioneer 7 data which have already appeared are given in the reference list. This does not include those publications by other non-GSFC associated authors who have used Pioneer 7 data.

3. Summary

The orbit of Pioneer 7 was such that for much of its early lifetime (several months) it was located in the aftward portion of the disturbed solar plasma caused by interaction with the geomagnetic field. Observations of the geomagnetic tail at the greatest distance yet achieved (1000 R_E) were performed by this experiment. (Ness et al., 1967; Fairfield, 1968). Important simultaneous correlated measurements of the electron component of the plasma in the neutral sheet and the associated magnetic field were first performed by Pioneer 7 (Lazarus et al, 1968).

The 30 second average detail data and hourly average data are available from the National Space Science Data Center at NASA-GSFC (Mail Code 601), Greenbelt, Maryland 20771. This present document provides, in summary graphical form, a working data set which was used internally at the NASA-GSFC and parts of which have been made available to other groups.

4. References (in chronological order)

1. Ness, N. F., C. S. Scearce and S. C. Cantarano, Probable Observation of the Geomagnetic Tail at 10^3 R_E by Pioneer 7, J. Geophys. Res., 73, 3769-3776, 1967. (Also X-612-67-183).

2. Lazarus, A. J., G. L. Siscoe and N. F. Ness, Plasma and Magnetic Field Observations During the Magnetosphere Passage of Pioneer 7, J. Geophys. Res., 73, 2399-2409, 1968.

3. Fairfield, Donald H., Simultaneous Measurements on Three Satellites and the Observation of the Geomagnetic Tail at 1000 R_E, J. Geophys. Res., 73, 6179-6187, 1968.

4. Ness, Norman F., The Geomagnetic Tail, Revs. Geophysics, 7, 97-128, 1969, (Also X-616-68-345).

5. Scearce C. S., C. Ehrmann, S. C. Cantarano and N. F. Ness, Magnetic Field Experiment: Pioneers 6, 7 and 8, X-616-68-370.

6. Ness, Norman F., The Magnetic Structure of Interplanetary Space, Proceedings Budapest XI International Cosmic Ray Conference, (Also X-616-69-334.)

7. Mariani, F., B. Bavassano and N. F. Ness, Magnetic Field Fluctuations in the Magnetosheath Observed by Pioneer 7 and 8, J. Geophys. Res., 75 6037-6049, 1970 (Also X-616-69-541).

List of Figures

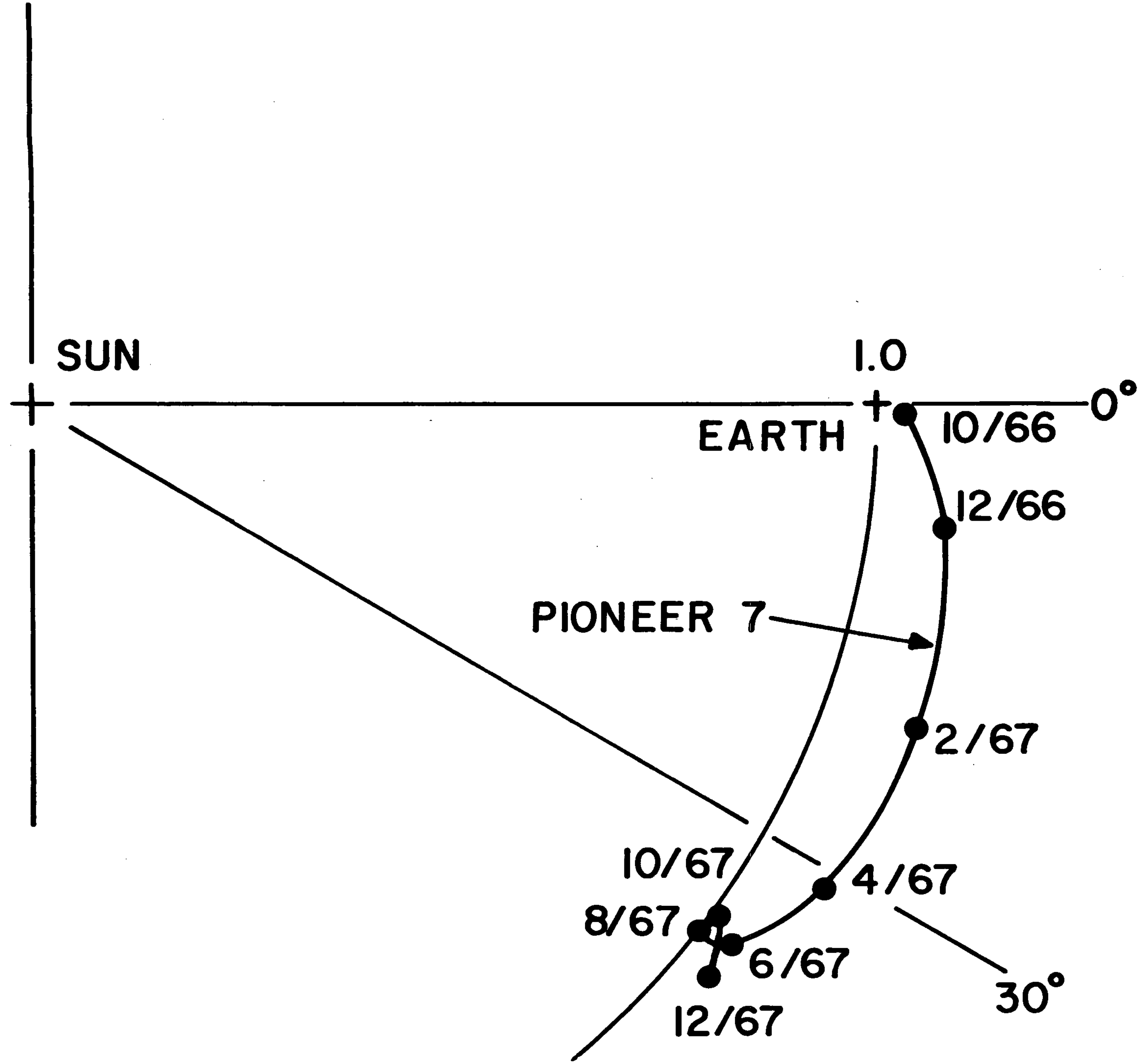
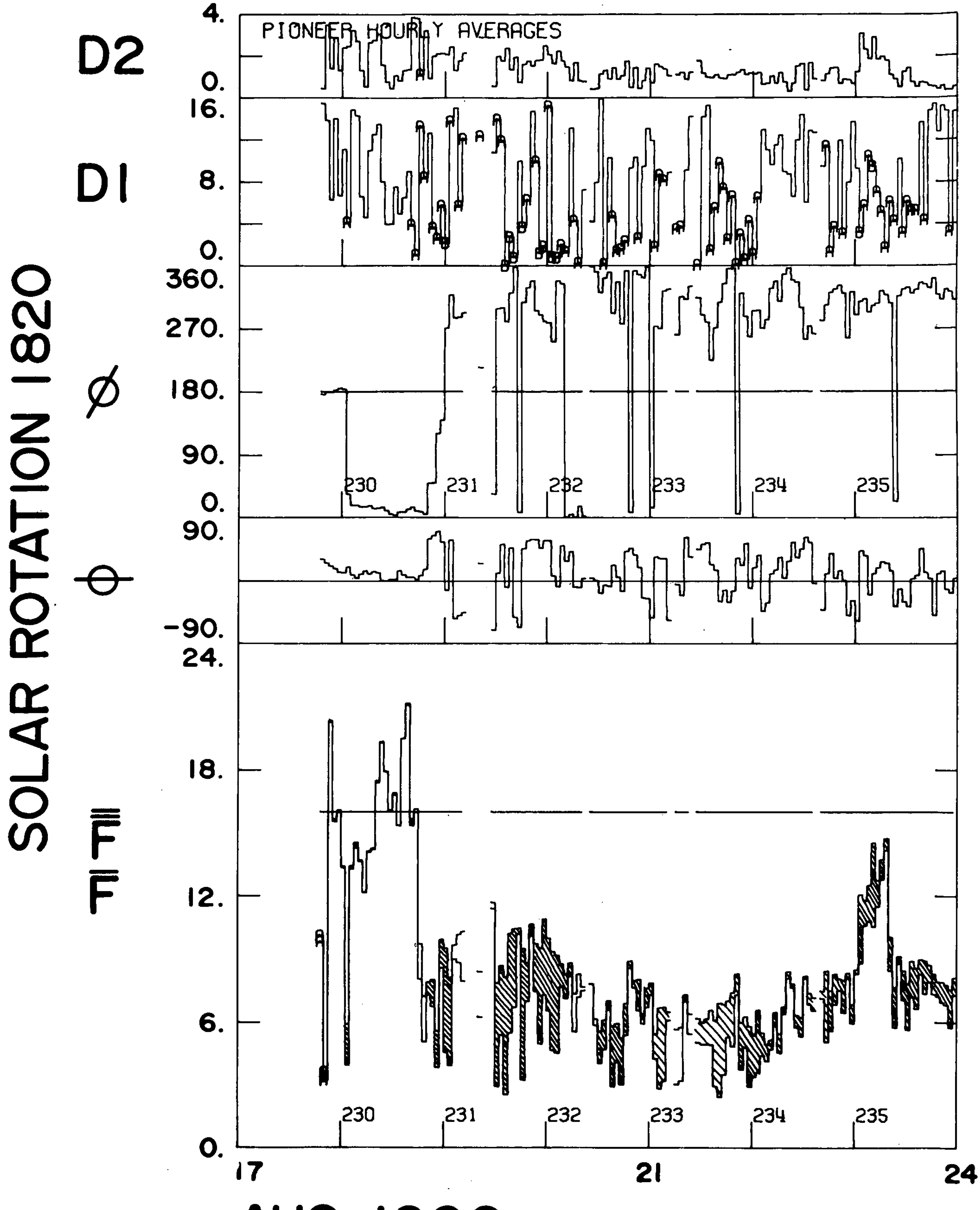


FIGURE 1



PIONEER HOURLY AVERAGES
SOLAR ROTATION 1820
D2
D1
ø
θ
|F|
F
4.
0.
16.
8.
0.
360.
270.
180.
90.
0.
90.
-90.
24.
18.
12.
6.
0.
230
231
232
233
234
235
17
21
24
AUG. 1966

FIGURE 2

FOLDOUT FRAME 1

FOLDOUT FRAME 2

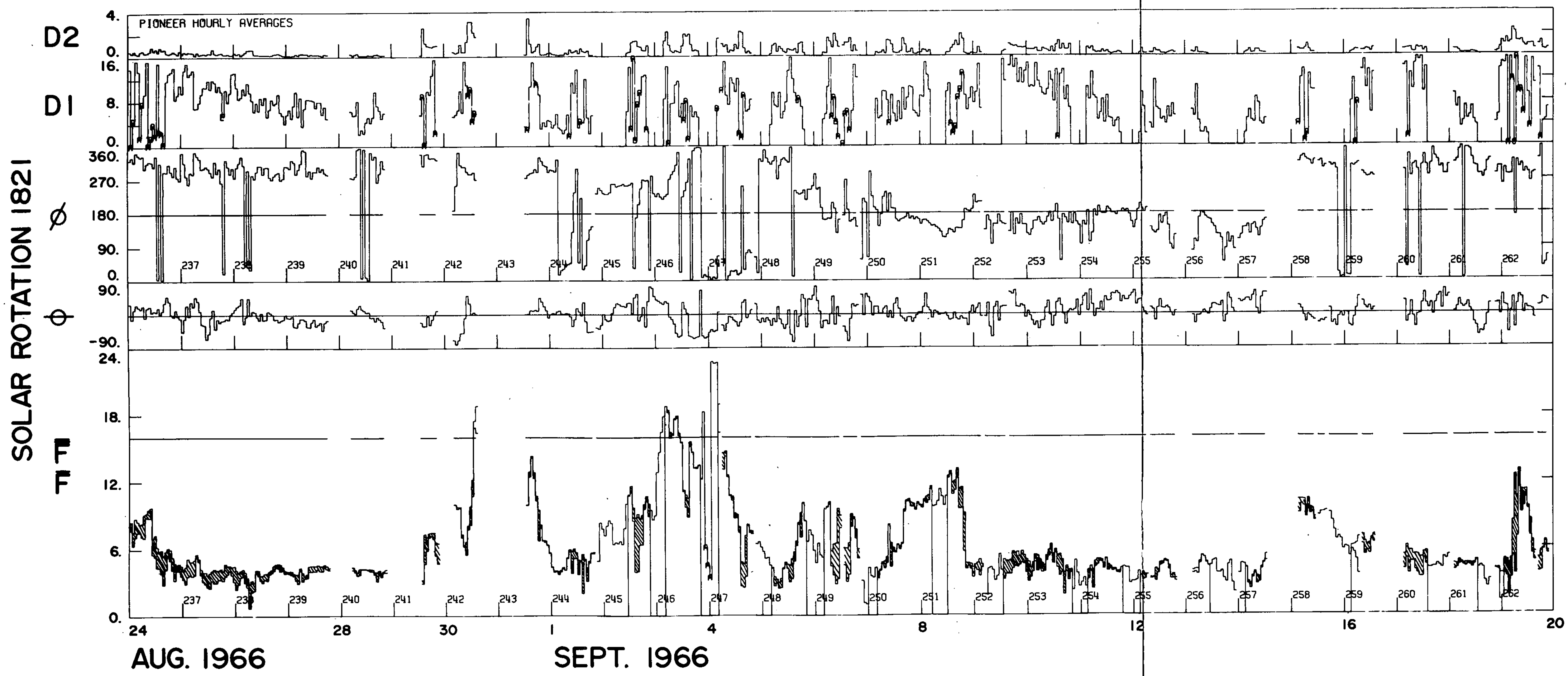


FIGURE 3

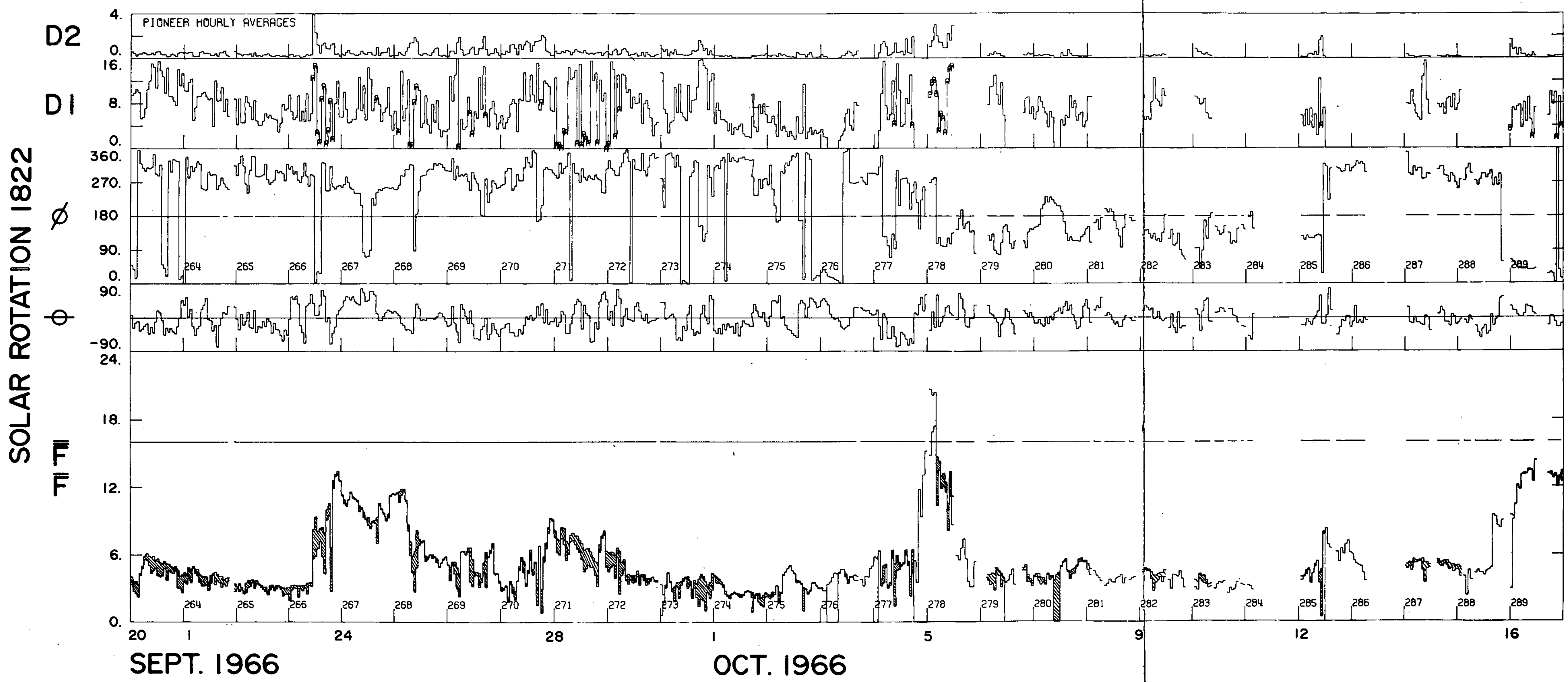

PIONEER HOURLY AVERAGES
D2
D1
SOLAR ROTATION 1822
SEPT. 1966
OCT. 1966

FIGURE 4

FOLDOUT FRAME 1

FOLDOUT FRAME 2

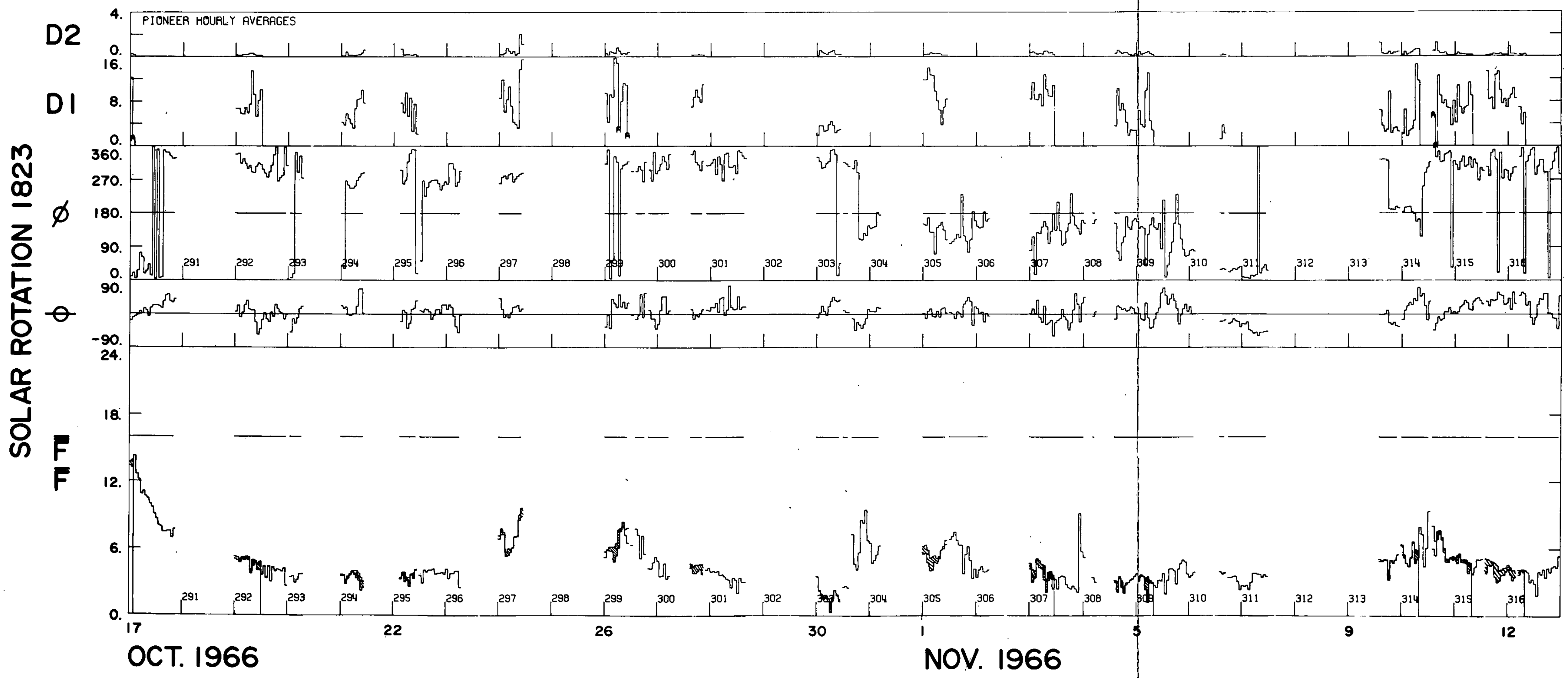


FIGURE 5

FOLDOUT FRAME 1

FOLDOUT FRAME 2

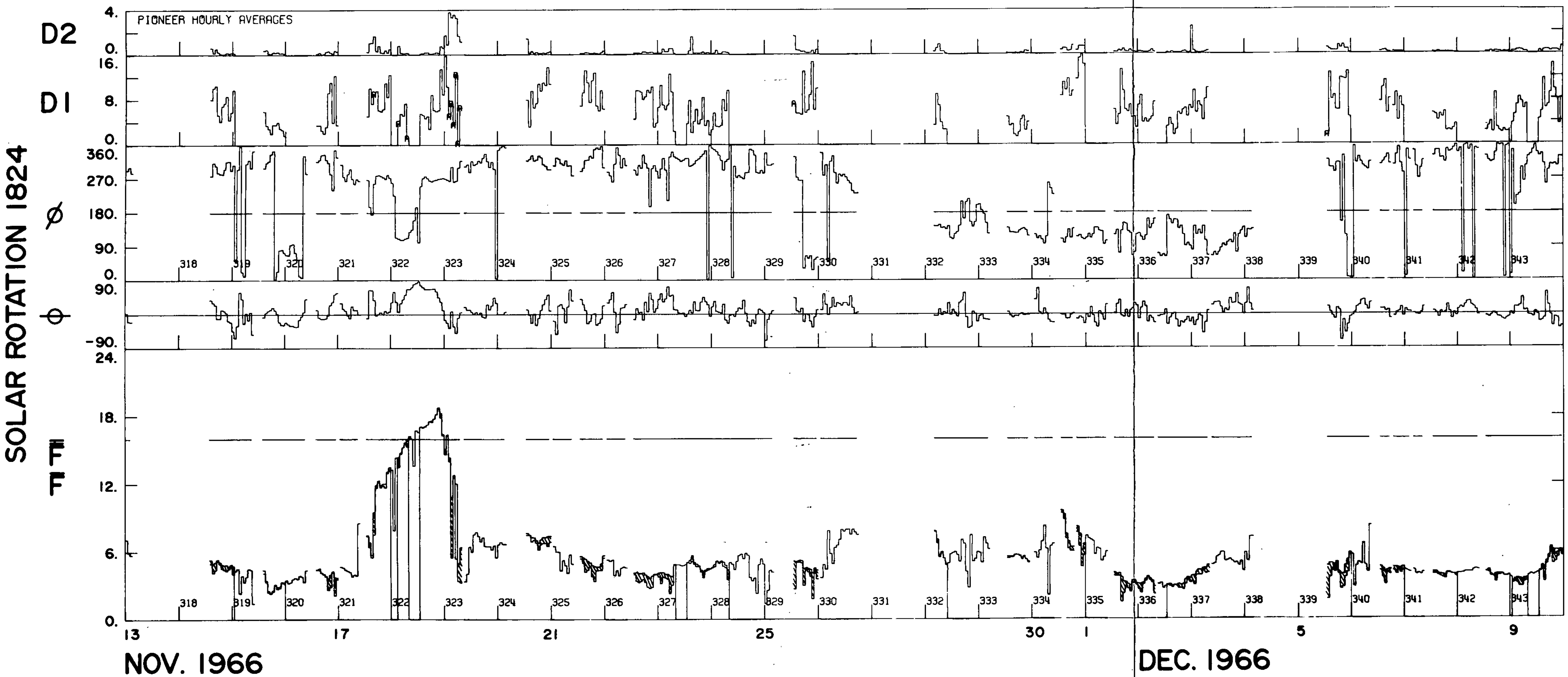


FIGURE 6

FOLDOUT FRAME 1

FOLDOUT FRAME 2

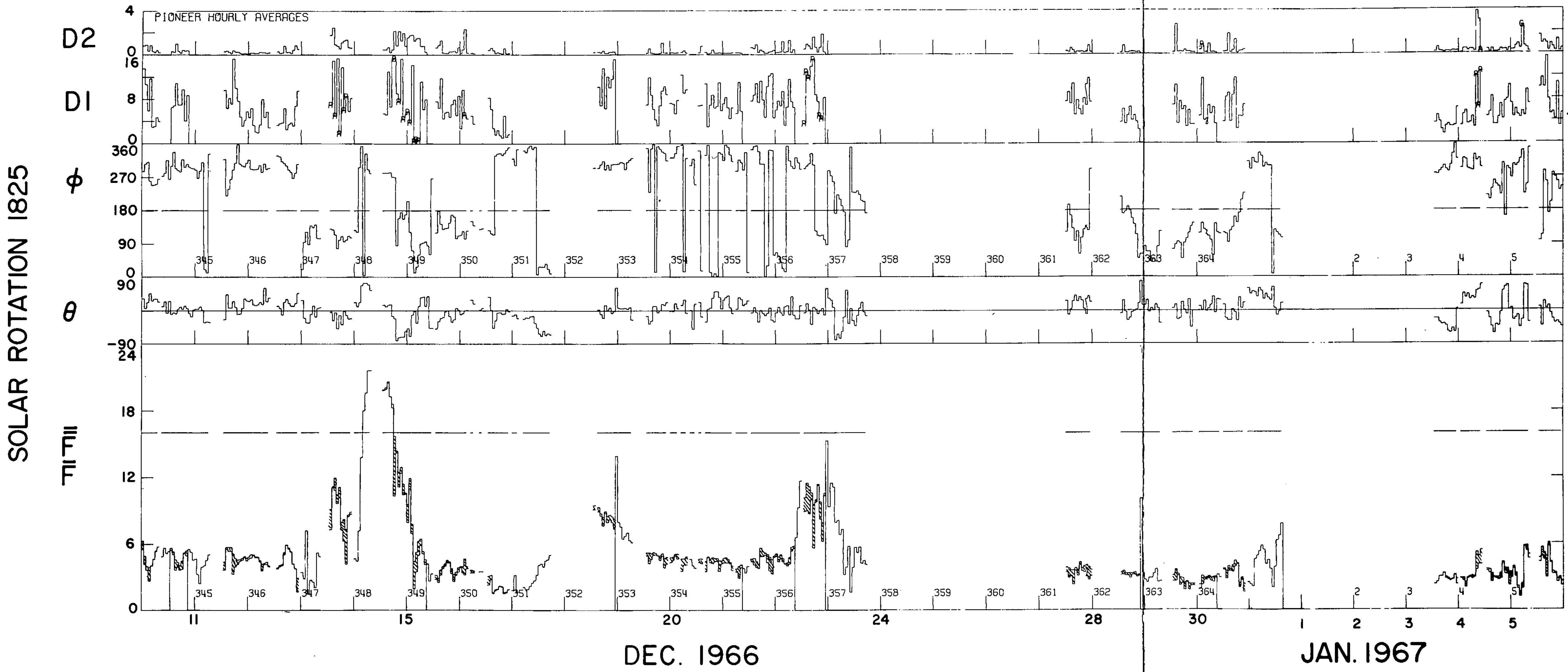


FIGURE 7

FOLDOUT FRAME 1

FOLDOUT FRAME 2

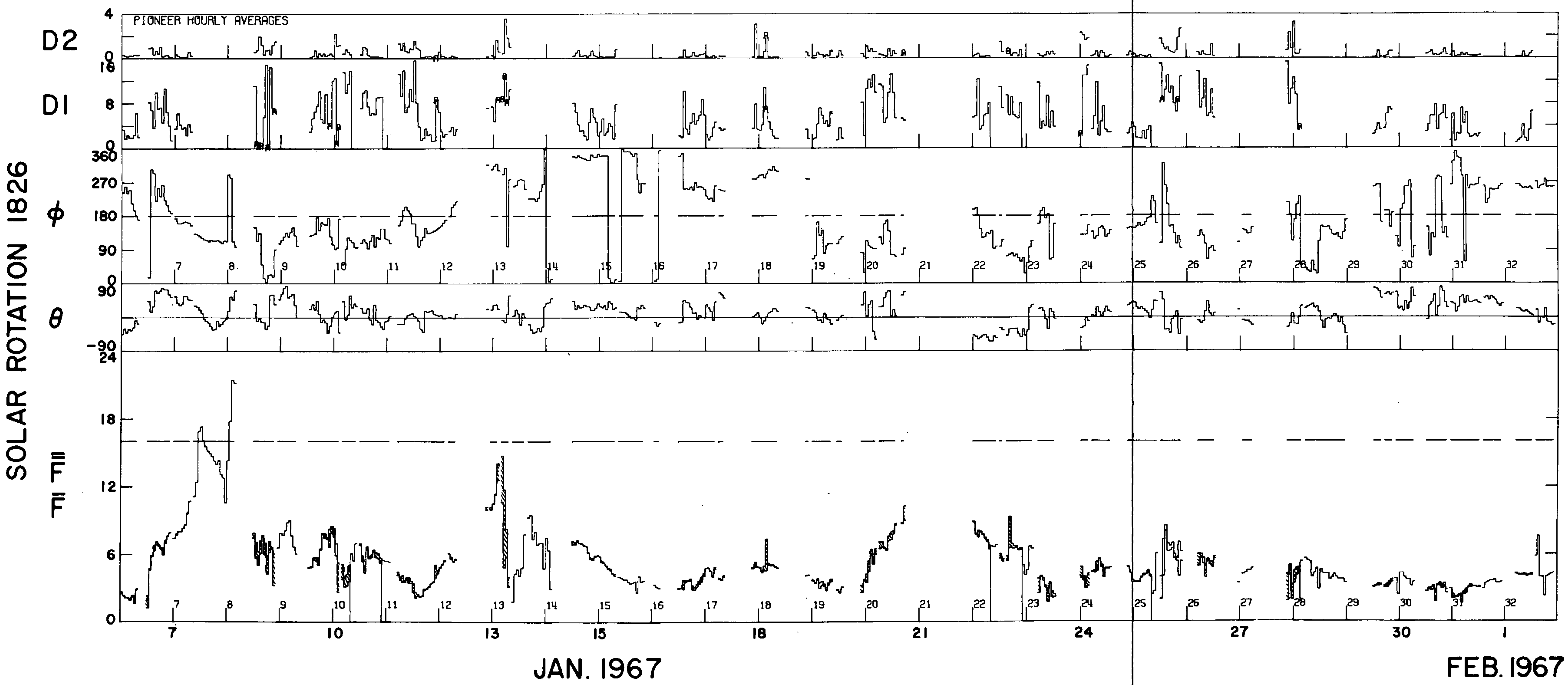


FIGURE 8

FOLDOUT FRAME 1

FOLDOUT FRAME 2

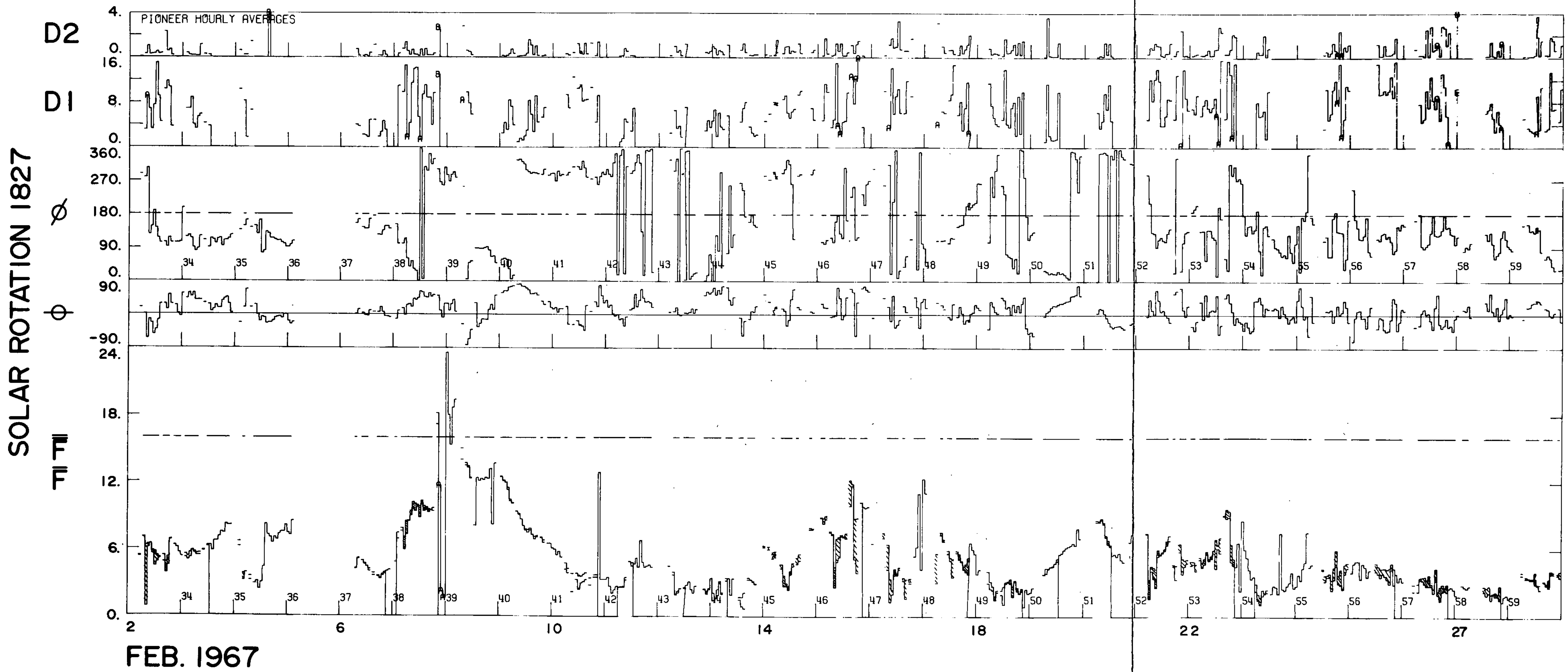


FIGURE 9

FOLDOUT FRAME 1

FOLDOUT FRAME 2

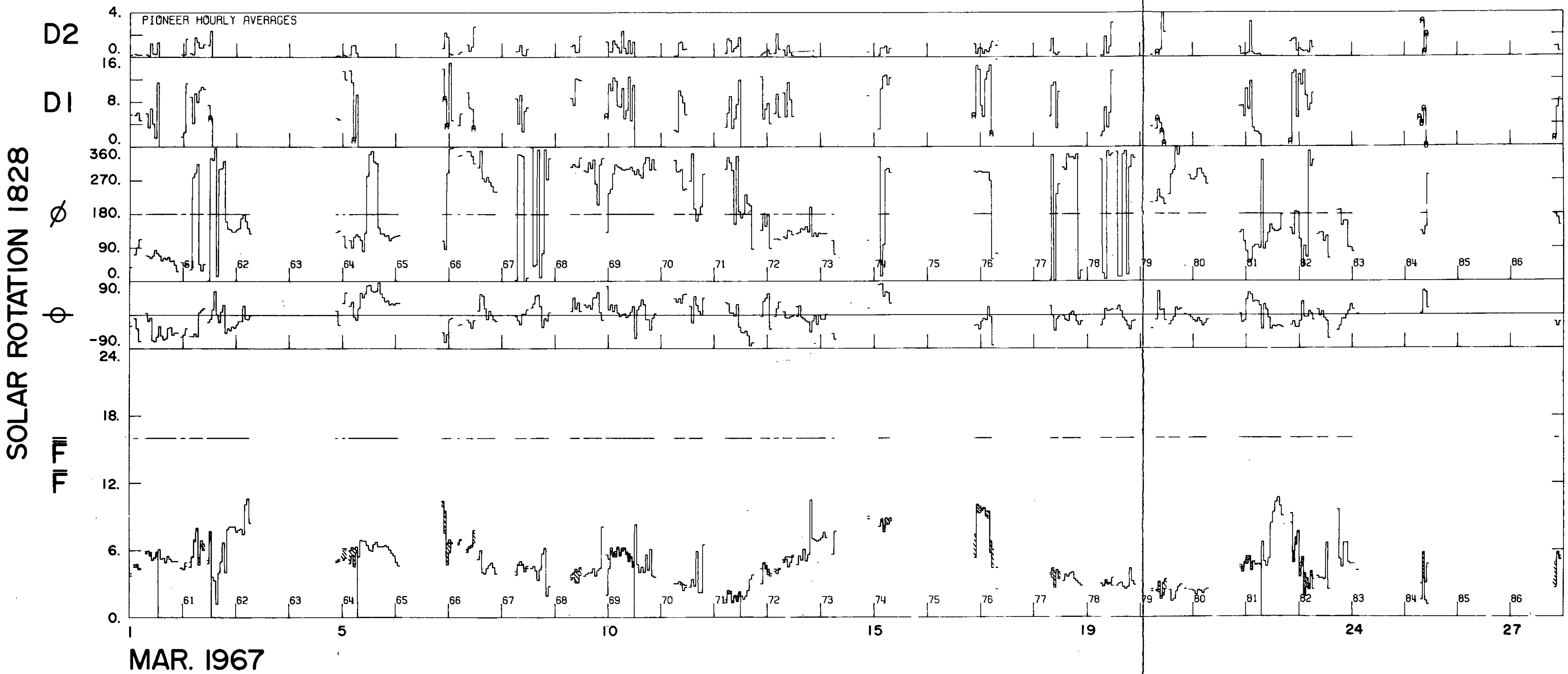


FIGURE 10

FOLDOUT FRAME 1

FOLDOUT FRAME 2

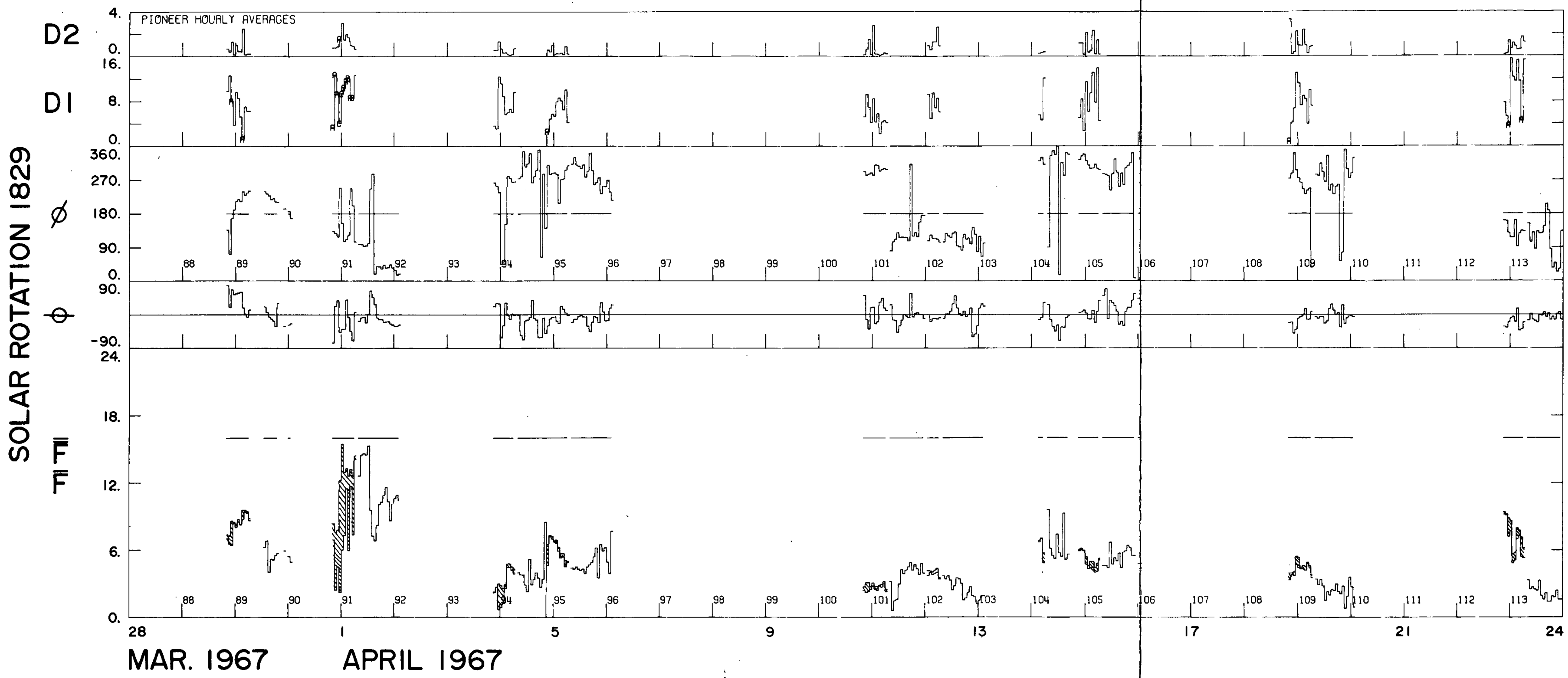


FIGURE 11

FOLDOUT FRAME 1

FOLDOUT FRAME 2

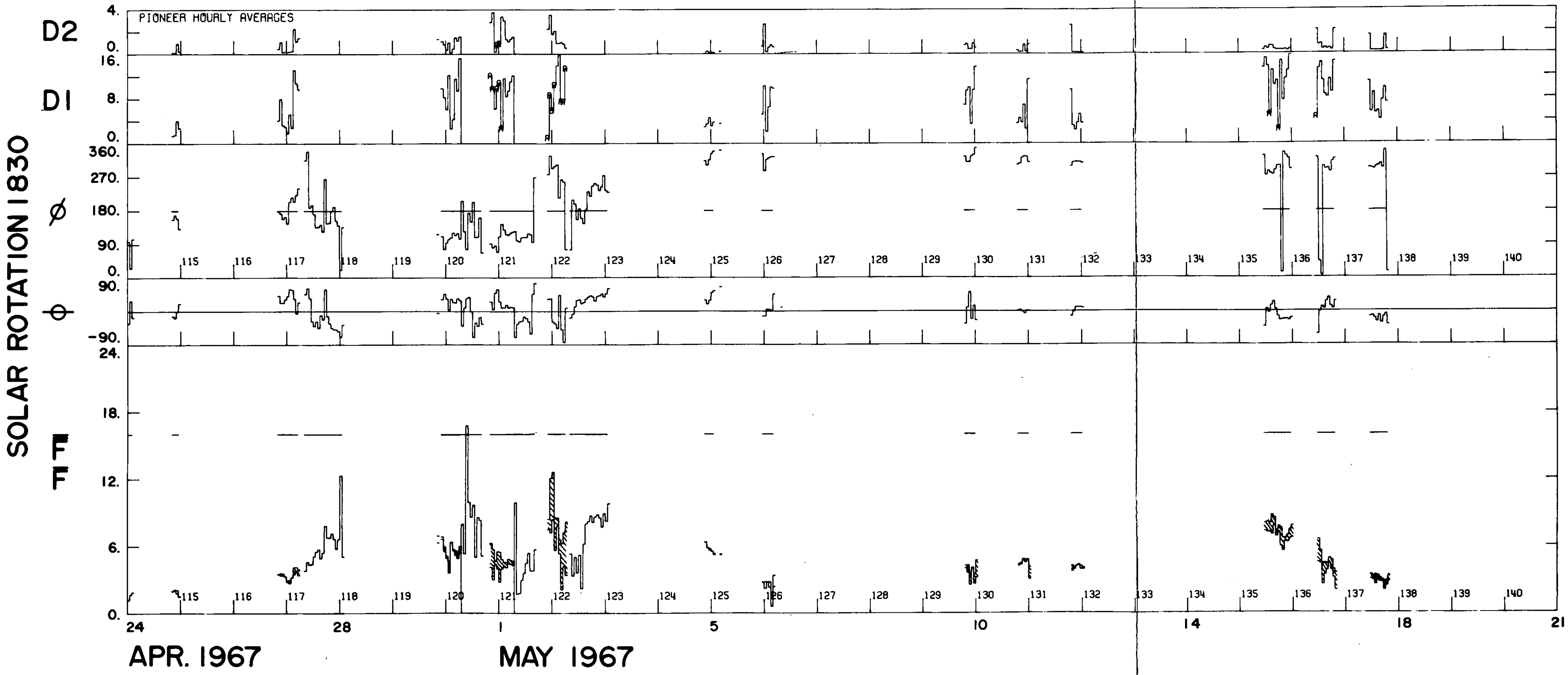


FIGURE 12

FOLDOUT FRAME 1

FOLDOUT FRAME 2

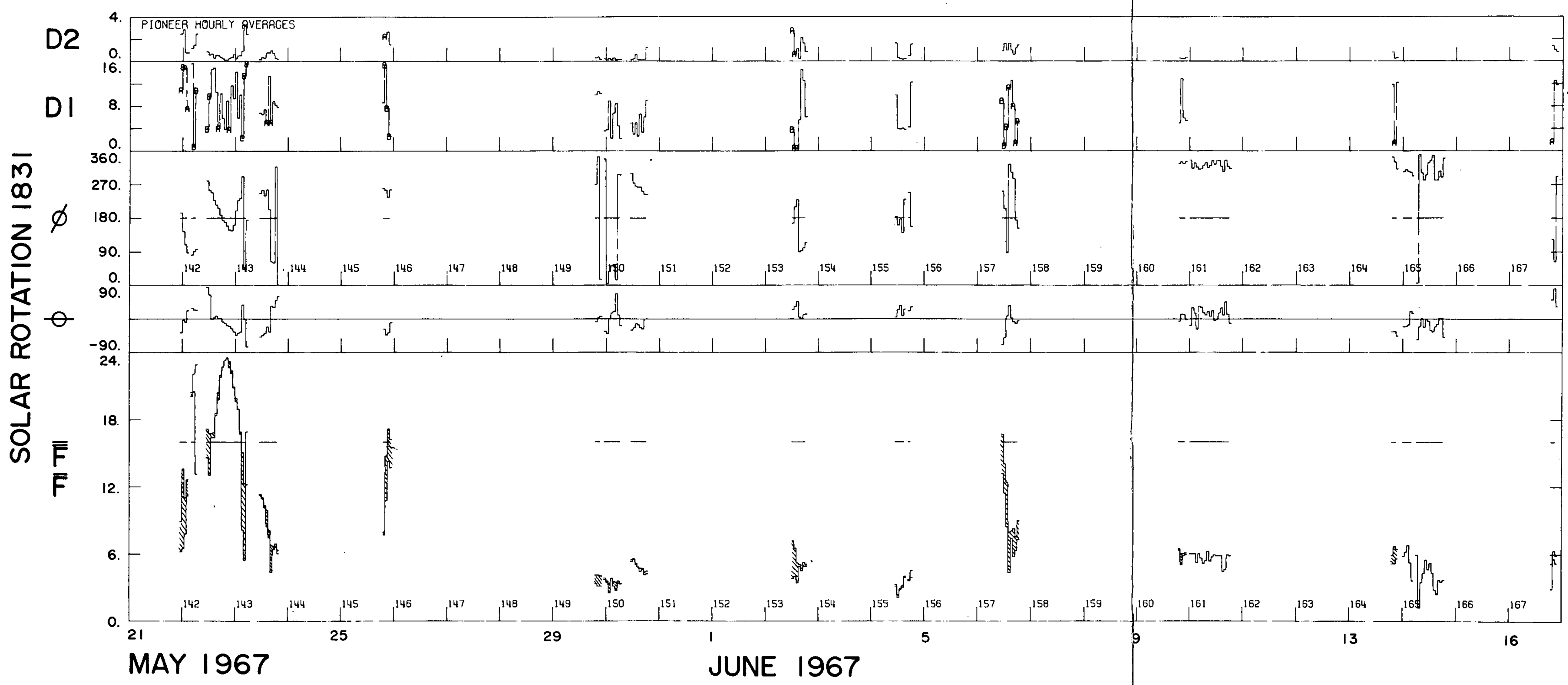


FIGURE 13

FOLDOUT FRAME 1

FOLDOUT FRAME 2

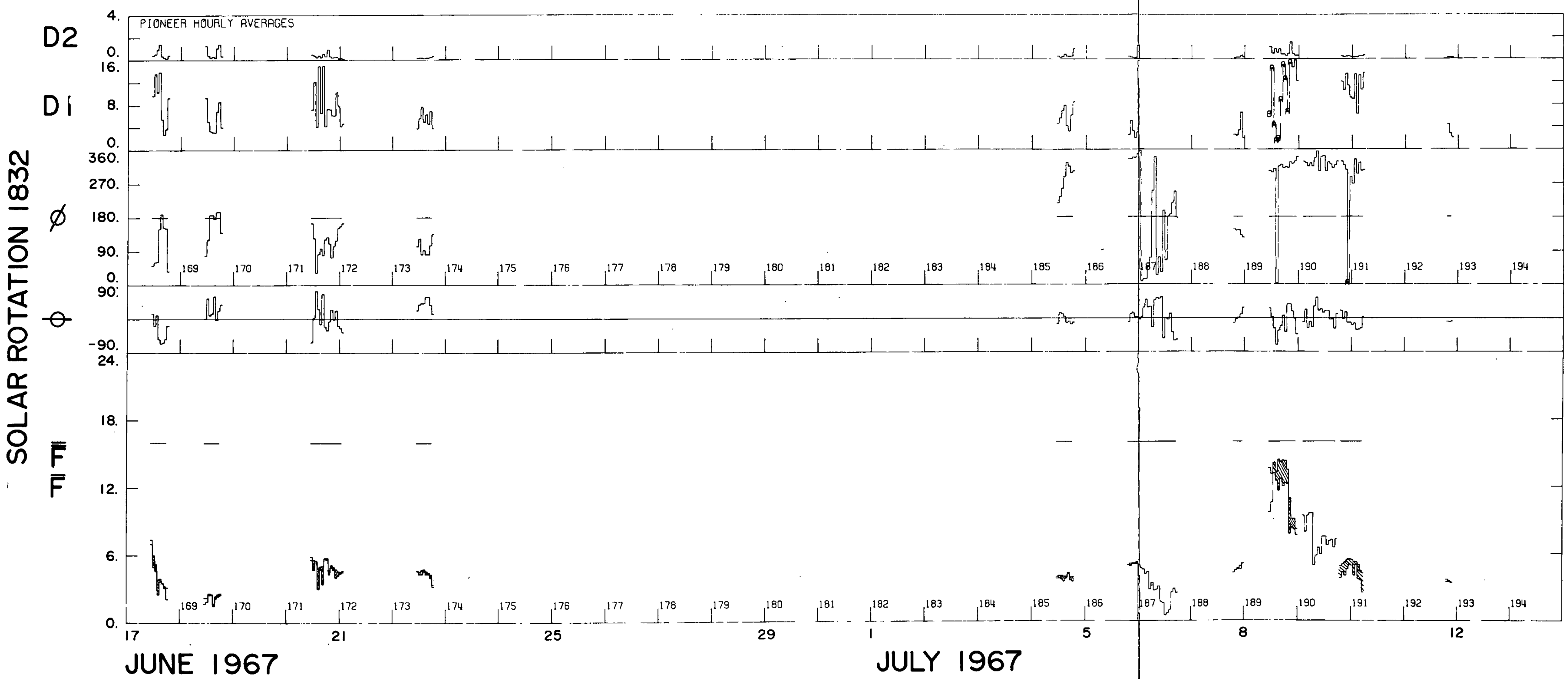


FIGURE 14

FOLDOUT FRAME 1

FOLDOUT FRAME 2

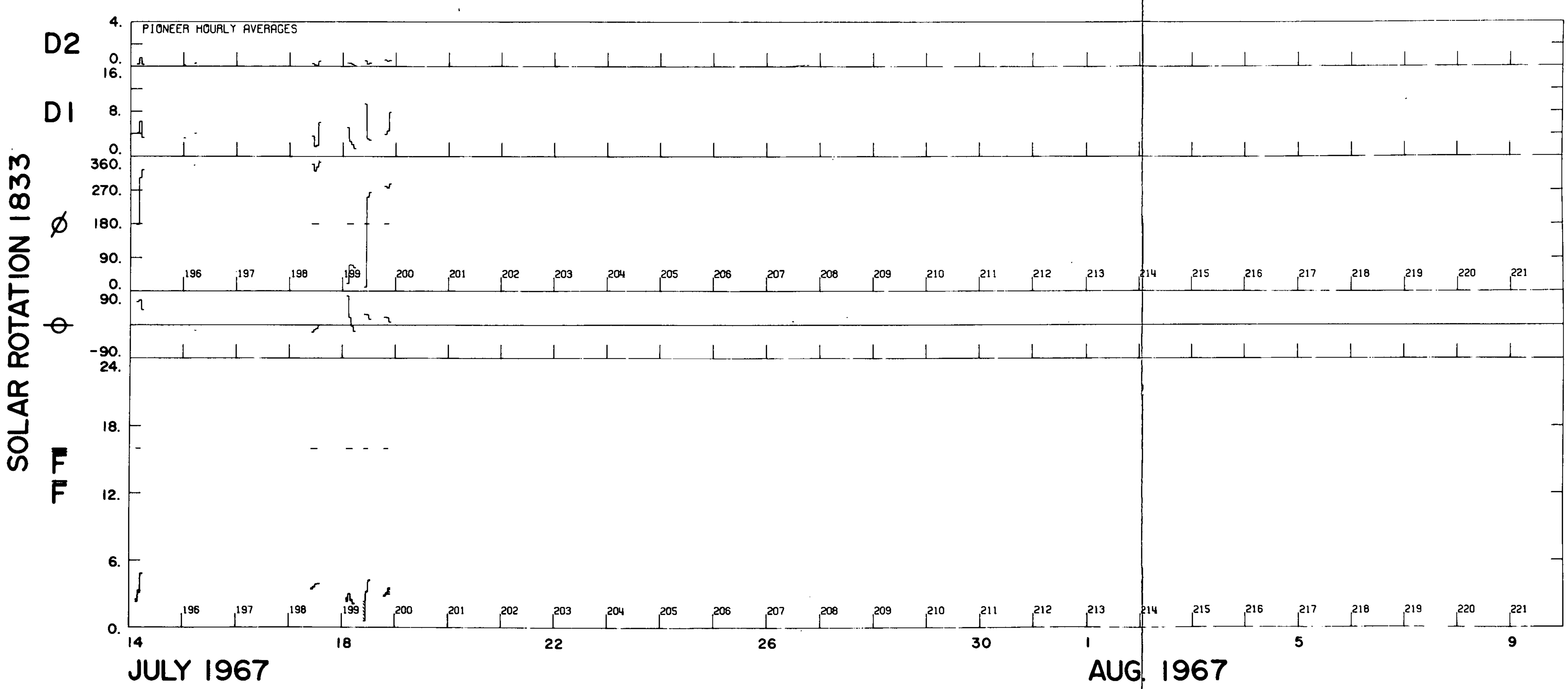


FIGURE 15.

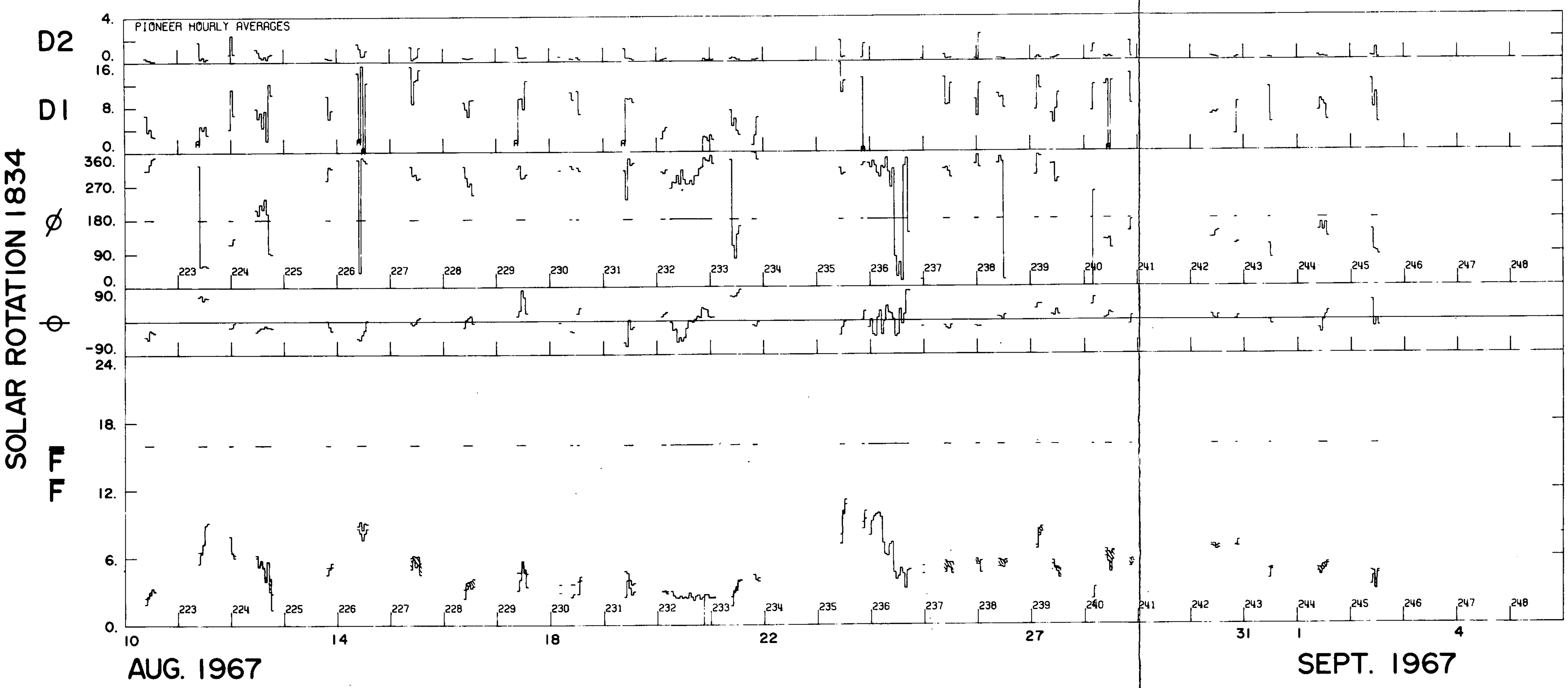

PIONEER HOURLY AVERAGES
D2
D1
Ø
θ
F
SOLAR ROTATION 1834
AUG. 1967
SEPT. 1967

FIGURE 16

FOLDOUT FRAME 1

FOLDOUT FRAME 2

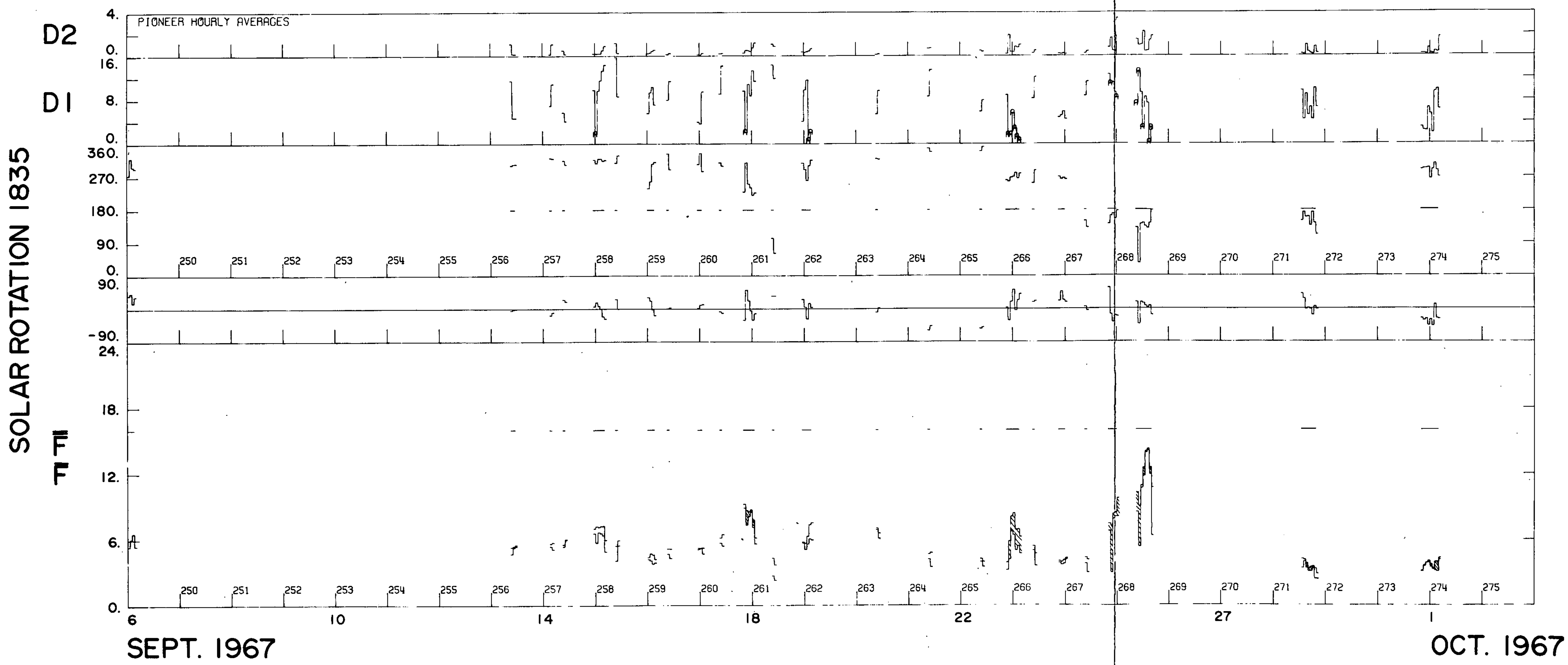


FIGURE 17

FOLDOUT FRAME 1

FOLDOUT FRAME 2

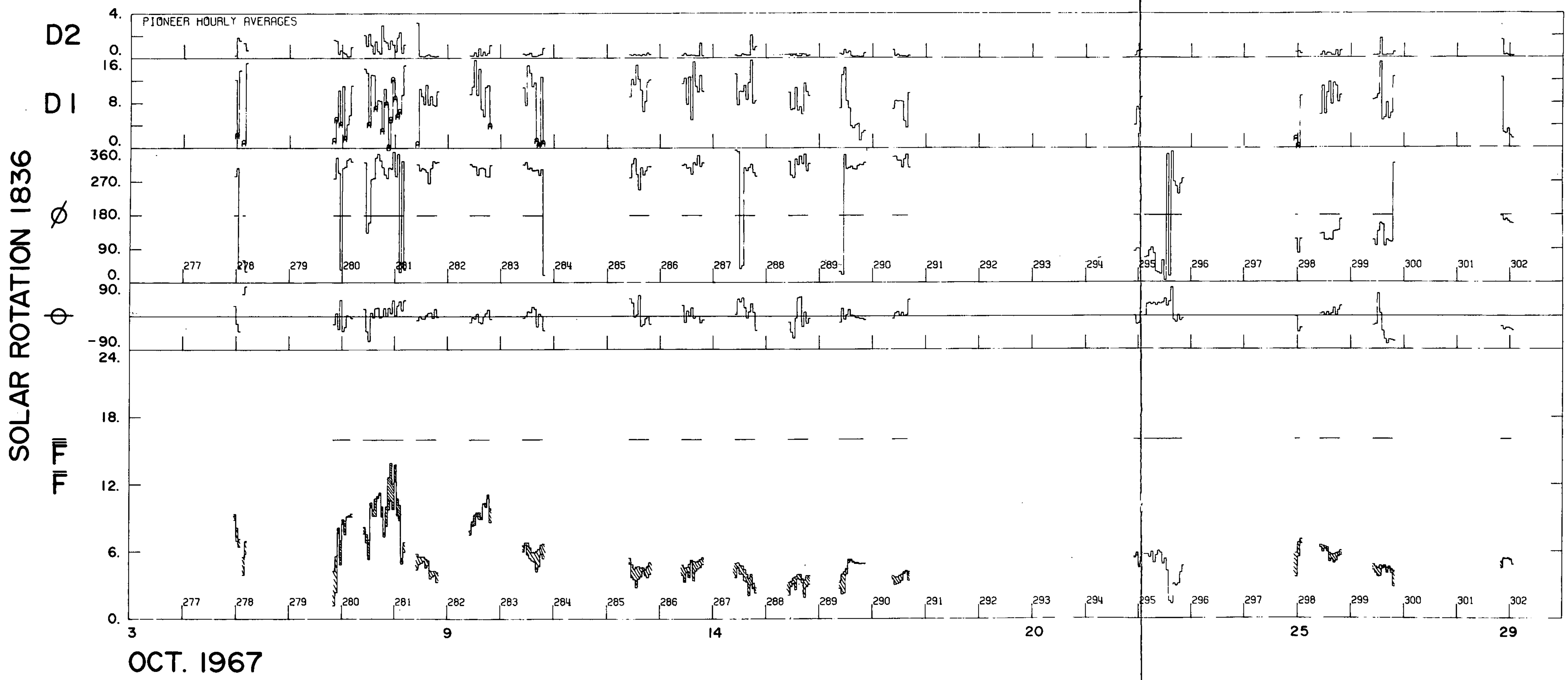


FIGURE 18